Software Tools for Sharing and Integrating GIS Data

July 27, 2006

Summary

The Washington Department of Transportation (WSDOT) in partnership with the Oregon Department of Transportation (ODOT), Ohio Department of Transportation (ODOT), Tennessee Department of Transportation (TDOT) and the Nebraska Department of Roads (NDR) are involved in a consortium of public and private entities for the purpose of developing computer based tools that facilitates geo-spatial transportation data sharing and integration for a multitude of purposes. The Geo-spatial Integration and Sharing Data Consortium (GISDC) is funded via a Transportation Pooled Fund (TPF) arrangement and managed by WSDOT.

The goal of the consortium is to develop, implement, and provide a variety of tools and procedures for sharing and integrating geo-spatial transportation data among state, county, city, and other jurisdictions in order to significantly reduce the time, effort, and expense of transportation projects in which integrated multi-jurisdictional and/or multi-modal data is required.
The primary goals of the project are:

- Design and implementation of a core database within the state as a central repository of multi-jurisdictional location data
- Translation of the data from one database to another including web-based interfaces for data providers and data users
- Integration of data from disparate data sources into a seamless whole
- QA/QC processes to monitor data quality, security, data entry and retrieval processes
- Documentation of a set of processes necessary to support data sharing from a variety of sources, e.g. data sharing agreements, agreement points.
- Documentation to support all technical aspects of the project.
- Linear Referencing Integration

The consortium is actively seeking the participation of other state departments of transportation who will benefit from the results of this project.
The initial timeline for this development is projected to be three to four years. Annual consortium meetings and electronic communication are being used to coordinate project activities. The specific product specifications and the scope of the project depend on annual funding available.

Background

For state transportation agencies location is an integral part of most data collected and utilized. Data with a location referencing element (e.g. address, route/milepost, GPS coordinate) can be used with a Geographic Information System (GIS) and placed on the roadway or other parts of the transportation system. Much of the useable data about transportation is not maintained at the state DOT level, but at the county, city or other local level or with other agencies. For planning, project scoping, environmental management, emergency management and other integral DOT functions it is often necessary to collect and combine this data. Current circumstances make it difficult, time consuming, and expensive to do so. Many of these difficulties could be mitigated by the creation of a complete statewide transportation network and associated location referencing systems.

The Oregon Department of Transportation (ODOT) and the Washington State Department of Transportation (WSDOT) have begun projects to collect and integrate local and state agency data

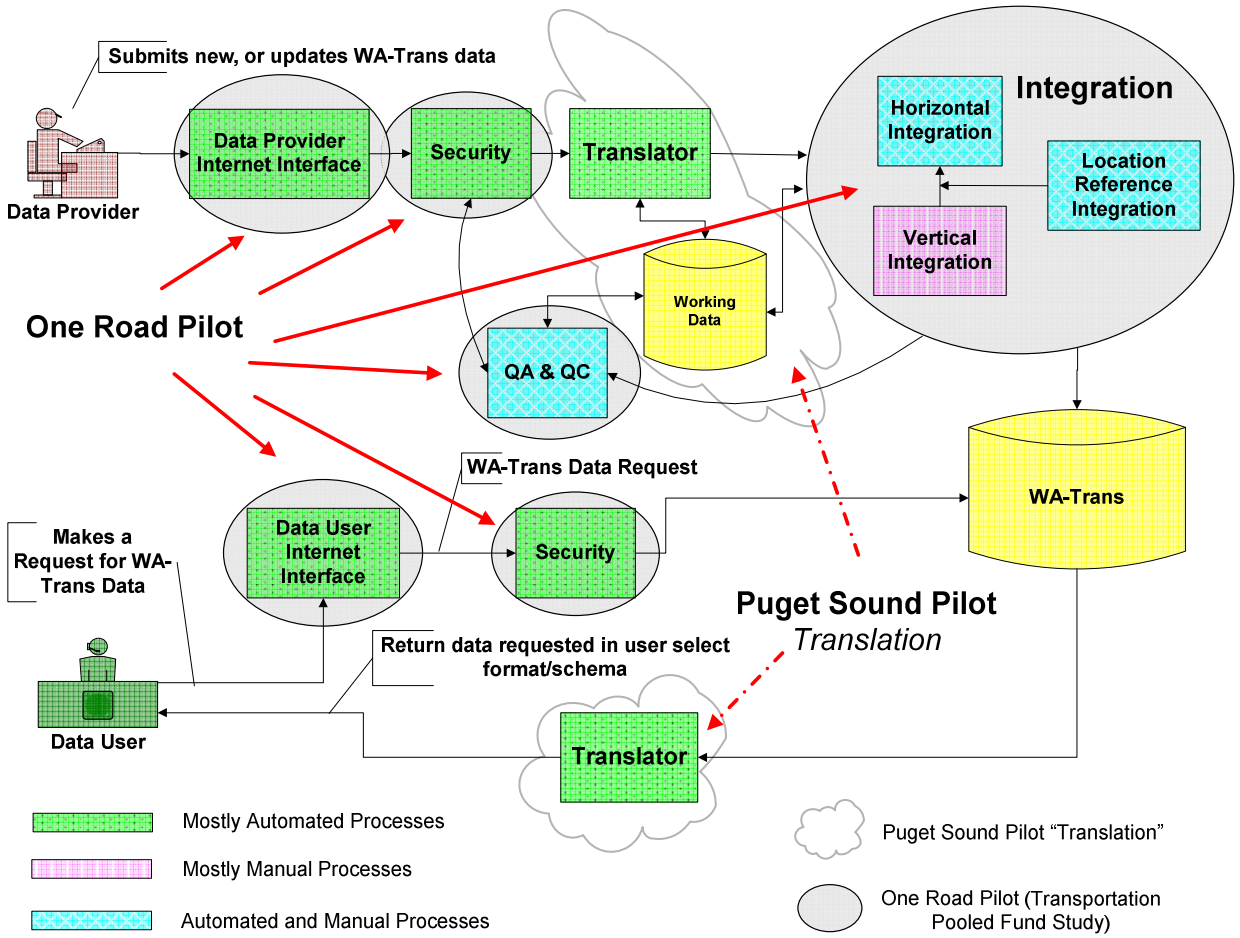
statewide, for GIS, known as a "Transportation Framework". (The Ohio Department of Transportation (ODOT) is well into transportation network projects.). In Washington the project is called "WA-Trans", for Washington State Transportation Framework. The technical aspects of this project involve the development of a core framework database that will meet the needs of many participants, establishing translation and integration software – using off-the-shelf products when possible and developing custom software when necessary, establishing QA/QC and security procedures, and documenting the whole process. Because it is necessary to include as many agencies and jurisdictions as possible, the system must be a dynamic one that can accommodate numerous data structures in a wide range of hardware and software environments.

The flexibility required to achieve these goals will allow this set of tools to be used, possibly with minor modifications, in virtually any state transportation department, especially if that state is a participant in the shared pool. The more participants and resources involved, the easier it is to develop the most dynamic and flexible tools. A description follows of each proposed tool, how it interacts with the other tools, and the potential data upon which it could operate. The consortium is currently involved in the One Road Pilot, which is the pilot implementing the phases described in this document.

Data to be managed with these tools include includes:

- Roads: State and Local roads, ramps, rest areas, location, number of lanes, federal functional classification, ADT, speed limits, address ranges, zip codes, local road identifier, route number, road name(s), location along roadway (milepost), and their geographic representation;
- Railroads: location, type of track (mainline, siding, etc.), train stations location, classification, line identifier, type of crossing, and their geographic representation;
- Ferries: route location, terminal location, route name, federal functional class, staging areas, route length, international or domestic route, average sailing duration, etc.
- Aviation: Airport identifier, surface type. Instrument landing approach, arc code, runway width, use, elevation, FAA Classification, Airport name, terminal location, etc.
- Non-motorized: includes bikes, foot, horses, etc. Includes location, name, type of usage, etc.
- Ports: location, routes for water transportation (particularly river and Puget Sound)
- Other data as yet not defined.

Consortium Focus Areas (One Road Pilot)



Translation (Phase I)

A major part of the Transportation Pooled Fund Project involves the development of a dynamic, flexible, bi-directional translator that will convert data from standard GIS, from CAD and other systems/schemas to a common format where it can be integrated, then translated out to most GIS schema and any of the original formats. The translation process will be able to convert GIS vector data with attribution and location referencing from one format into another.

There is no off the shelf software that will perform all the translation functions needed by the One-Road Pilot. In the Puget Sound Pilot translation processes were researched with one translation software product. The One-Road Pilot will take the lessons learned in the Puget Sound Pilot and use those processes with other vendor's software with the goal to choose one product. There will necessarily be customization involved with the translation software chosen. Once that product is selected customization can be performed to allow for more automation and also integration with a Data Provider and Data User Interface. The translation process will need to have a friendly user interface to set up the initial data exchange process and to store that setup structure so it could be reused to update and maintain the data. The translator will also need to check the data for simple constraints to ensure it meets basic requirements as defined by the standards and the parties involved. A user friendly

translation process will allow the combined dataset to be used by any organization, e.g. governments, public utilities, contracting firms, etc. that maintains data structures for which translation is available.

Data Provider Internet Interface (Phase I)

Data providers will have an Internet interface to the translator. This interface will allow them to create and to modify the translation process to meet the needs of their particular data structures – for example, if they change the table structure of their local database, they will be able to alter the translation tools to reflect those changes. They will be able to upload and update the framework data as their local data changes. Updates will probably occur on a regular basis, based upon arrangements between data providers and data users. In the case of ODOT and WSDOT the local governments will provide the data to the transportation framework system. Security procedures will be in place to prevent unauthorized access to the data provider interface.

Data User Internet Interface (Phase I)

Data users will have an Internet interface to the fully integrated statewide transportation framework that allows them to view and to download data, by translating the data to their desired format.
They will be able to:

- Select the geographic region for the data they wish to view/download,
- View the metadata for that selection. Metadata is information about data such as the time the data was collected, the spatial accuracy of the data, the projection and coordinate systems of the data etc. NOTE: Metadata from the original providers and for the current data will be maintained.
- View the geographic data they have selected.
- Download the data in a user selected format.

The security system will make sure they are authorized to access that data. A disclaimer will be provided regarding the limitation of the data. The translator will be available for formatting the data and projecting it as needed by the data user.
NOTE: The user interface is a "read only" interface that allows viewing and downloading data. The actual use and manipulation of any framework data subset is done after it has been downloaded. Once they have downloaded the data they can then incorporate it back with their own GIS transportation data and use it accordingly.

Data Integration (Phase I – requirements & feasibility, Phase II – implementation)

The data that ODOT and WSDOT expect to receive from the various agencies will be linear data that represents roads and other transportation modes, with data fields, called attributes that describe characteristics of the roads such as number of lanes, federal functional class, pavement type, etc. The data also includes location referencing information such as addresses, route names, and mileposts. Location referencing allows data items to be assigned to specific places along the transportation segment.

Because data comes from various sources and each source collects and stores data differently, it may not "match" at jurisdictional boundaries. When displayed on a map a road in one county may appear to just end when the same road in another county may appear to just begin. One road may be disjointed, and doesn't connect at all where it crosses a jurisdictional boundary, when in reality it is a single

continuous roadway. Even within a specific jurisdiction there may be multiple providers of road data causing similar problems. Fixing this problem is referred to as "edge matching" or horizontal integration.

There are other types of mismatch. Making sure that the most accurate and complete database attribution is correctly linked across various transportation modes (highways, rail, ports, airports) or to other "levels" (the power grid, water lines, cadastral information, etc) is referred to as vertical integration. Tools built to facilitate both horizontal and vertical integration are useful not only for a transportation framework, but for any linear based GIS data and related attributes.

Quality Assurance and Quality Control (Phase II)

Quality assurance and quality control (QA/QC) processes and tools establish and enforce data consistency and data accuracy. This is especially critical in an environment where data is being integrated from multiple sources and distributed to multiple users. Much of the QA/QC function can be automated in the following categories:

- Topological – checks regarding connectivity of the line work at intersections, overpasses and bridges represented as separate features, arcs meeting at jurisdictional boundaries, etc.
- Scale/Spatial – Does the location accuracy meet the planned business use of the data; does the "aesthetic" representation of the transportation feature meet the business requirements?
- Attribute – Are the minimum required fields included, are the field descriptions met, how many of the attributes are populated, are the attribute values valid?
- Metadata – Concerns regarding metadata include: has the required metadata been provided, is it complete, does it conform to established metadata standards; does the metadata match the layer?

In areas where automation is not useful or appropriate, "manual" processes will be established and documented.

Security (Phase II)

Data security is required for both data providers and for data users. Data uploads and modifications may only be done by authorized providers. In addition, data entry and modification must be done through a secure system. On the data user since, while it is anticipated that transportation framework, data is generally publicly available, some business situations (such as statewide E-911 dispatch) require that private data be used. Thus access to sensitive data must be secured against anyone except those authorized to use it. For uses other than transportation framework it is important that security be available.

Location Referencing Integration (not yet scoped)

When building GIS for transportation infrastructure, a major business need is to be able to locate things along the infrastructure network. This is achieved through location referencing. Washington State employs multiple forms of location referencing:

- WSDOT and counties use a form of route/milepost points for location referencing,
- Counties and cities use addresses,
- Cities also use distance from intersection

- All use GPS for various purposes.

In order to accurately place data items on a roadway, some form of linear referencing is necessary. In order to relate data items' locations to each other, it is necessary to be able to relate the linear reference of each to the other. This will facilitate geocoding across the state and locating things by a variety of methods, meeting a variety of business needs. Software tools that support location reference integration will be critical when bringing outside data of any sort into any GIS system and then trying to use that data to locate features along a transportation network.

Although local location referencing will be provided with data, that location referencing will not always be consistent between data providers and across boundaries. In order to have a single location referencing system for the whole state, a consistent system must be applied to the data during integration.

The Need for a Consortium

In order to complete the full suite of tools, processes, and documentation, a consortium of supporting members needs to provide consistent, continuing support, feed back and funds for a period of three to four years. It is hoped that members will also provide creative input, possibly time for testing, and other processes that will move the project forward. The consortium will provide implementation opportunities for tools developed during this effort and the documented processes that establish the foundation for an integrated, maintainable statewide transportation network for each interested member.

Consortium Benchmarks

The GISDC is designed to be action oriented with the primary focus being the development and implementation of tools that facilitate sharing and integration of geo-spatial transportation data and testing of those tools with a variety of data formats and sources from a variety of geographic locations. It is important that complete documentation of all tools be provided including through conferences and refereed publications. Thus, papers will be developed as appropriate and submitted to organizations such as the Transportation Research Board (TRB), GIS-T and URISA for review, presentation, and publication. It is hoped that the Consortium members will co-author these papers. Consortium members will directly benefit from the software tools and processes that can be designed to meet their specific needs.

Consortium Management

The pooled fund lead states are Washington and Oregon. Funding for the Consortium is arranged through WSDOT through the Transportation Pooled Fund. Each consortium member has designated one individual to serve on the GISDC Advisory Team. The team guides the work of the GISDC. Meetings are held annually and electronic communications in addition to periodic conference call meetings serve to bind the team together between meetings.
Some of the tasks of the GISDC are to:

- Gain knowledge of existing software to determine which requirements can be met with off-the-shelf products, either as is or customized, and which requirements will require software developed from scratch, or COTS customization.
- Establish minimum requirements for each tool.

- Recommend the preferred way of communicating between the GISDC members and the research team.
- Establish periodic meetings and workshops. Day to day operations will be guided by interactions with the lead states of the Consortium.
- If consortium members choose to actively participate in the Pilots the GIDSC will provide guidance and communication processes. Active participation in Pilots by all consortium members is encouraged.

Current Commitments and Estimated Funding Requirements

Category	Year 1	Year 2	Year 3	Year 4
Current Commitments:				
Washington State DOT	$30k	$30k	$30k	
Oregon DOT	$70k	$30k	$30k	
Tennessee DOT	$65k			
Nebraska DR	$30k	$30k	$30k	
Ohio DOT	$30k	$30k	$30k	
Current Commitment Totals	$225k	$120k	$120k	
Additional estimated needs and possible funding sources through the Transportation Pooled Fund:		$210k $30k	$210k $30k	$210k $30k
State DOT (need 7 to participate in AT - $30k per year)	TBD	TBD	TBD	TBD
State DOT (possible 3 not participating in AT- $10k per year)				
Private Industry				
Total estimated funding needed	$225k	$360k	$360k	$240k

Current commitments have been completed for year 1 funding. Current commitments for year 2 funding are nearing completion. Washington State DOT, is the pooled fund lead. Budgets for years 2 through 4 in the table above represent estimated requirements to complete the project. Additional contributions will accelerate product development and possibly expand the scope. It is anticipated that funding for the entire project will not exceed $900 thousand total over the three to four year period.

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